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Description

BACKGROUND OF THE INVENTION

This invention relates to an ultrasonic probe having an ultrasonic propagation medium for use in medical ultrasonic diagnostic systems for examination and inspection within an examining body by transmitting and receiving ultrasonic signals.

Recently, an examination or inspection method using an ultrasonic propagation medium between an examining body or a human body and an ultrasonic probe which emits and receives ultrasonic signals has applied to the field of medical ultrasonic diagnostic systems or the like.

Such ultrasonic probes using an ultrasonic propagation medium are respectively disclosed in Japanese Laid-open Patent Application No. 58-7231 and at "Pages 347 to 348 of paper for 46th lecture of the Ultrasonic Medical Society of Japan, 1985". Referring to Figs. 1 and 2, the conventional ultrasonic probe utilzing such ultrasonic propagation medium will be described hereinbelow.

Fig. 1 is an illustration showing a trapezoidal scanning type of the ultrasonic probe, which can obtain a wide examining region in spite of a small contact area to an examining body. In Fig. 1, numeral 101 denotes an array of transducer elements, numeral 102 denotes an acoustic matching layer provided along the curved surface of the array 101 of the transducer elements, numeral 103 denotes an ultrasonic propagation medium arranged in front of the acoustic matching layer 102. Numeral 104 denotes lead wires respectively connected to the arrayed transducer elements, numeral 105 denotes cables which connect the ultrasonic probe to a body of an ultrasonic diagnostic apparatus (not shown), numeral 106 denotes an examining body, numeral 107 denotes a transmission ultrasonic wave, numeral 108 denotes reception ultrasonic wave, numeral 109 denotes an imagination origin, numeral 110 denotes a center of curvature of the arrayed transducer elements, and numeral 111 denotes an examining region.

The operation of the above-mentioned conventional example will be described hereinbelow.

As is apparent from this figure, the acoustic matching layer 102 and the array 101 of the transducer elements arranged in a convexed form are in plane contact with the examining body 106 such as human body by means of the ultrasonic propagation medium 103 provided in front of the matching layer 102. Moreover, the ultrasonic propagation medium 103 can increase the scanning angle of the ultrasonic waves, namely, enlarge the examined region. The ultrasonic waves 107 transmitted, in order, from each of the transducer elements of the array 101 are deflected in the human body 106, since an acoustic velocity in the ultrasonic propagation medium 103 is lower than that in the human body 106. The deflected ultrasonic waves are reflected within the body 106, and are received by the same transducer element which has emitted the waves. As is apparent from Fig. 1, in the ultrasonic probe, the examining region 111 of the ultrasonic signals in the body 106 is of a sector corresponding to a part of a circle whose center is designated at a point 109. This is because that the acoustic velocity in the ultrasonic propagation medum 103 is different from that in the human body 106.

Silicon rubber or the like is used as the above-mentioned ultrasonic propagation medium 103. Silicon rubber or the like has an acoustic impedance which is close to an acoustic impedance (about 1.5 to 1.6×10^5 g/cm^2.sec) of the human body 106 and an acoustic velocity (about 1000m/sec) which is slower than an acoustic velocity (about 1540 m/sec) of the human body 106.

As described above, in this ultrasonic probe, the examining region 111 is enlarged, and the contact surface of the ultrasonic probe with the human body 106 becomes flat. Therefore, there are advantages that the adhesion is good and the operation is easy.

Fig. 2 is a cross-sectional view showing the other example of the conventional linear scanning type of the ultrasonic probe. In Fig. 2, numeral 201 denotes a case, numeral 202 denotes an array of transducer elements provided at the front portion of the case 201, numeral 203 denotes a backing member provided at the rear portion of the array 202 of transducer elements, numeral 204 denotes lead wires respectively connected to the arrayed transducer elements 202, and numeral 205 denotes a cable connected to a body of an ultrasonic diagnostic apparatus (not shown). Numeral 206 denotes an examining body, numeral 207 denotes an ultrasonic propagation medium provided between the arrayed transducer elements 202 and the examining body 206. The ultrasonic propagation medium 207 comprises a flexible bag 208 made of silicon rubber or the like in which bag degassed water 209 is contained.

The operation of the above-mentioned conventional example will be described hereinbelow.

Each of the arrayed transducer elements generates ultrasonic waves in order, with pulse voltage transmitted from the body of the ultrasonic diagnostic apparatus through the cable 205 being applied. The resulting ultrasonic waves are emitted to the examining body 206 through the ultrasonic propagation medium 207. The ultrasonic waves reflected within the examining body 206 are received by the transducer element which

emits the ultrasonic waves, and are changed to electrical signals. The electrical signals are sent to the body of the ultrasonic diagnostic apparatus through the cable 205, and are processed so as to display an ultrasonic image.

By providing the ultrasonic propagation medium 207 between the examining body 206 and the potion for transmitting and receiving the ultrasonic waves, it is possible that the resolving power of the ultrasonic image in the vicinity of the transmitting and receiving portion or the surface of the examining body 206 is improved. Moreover, even if the surface of the examining body 206 has irregularities, the ultrasonic porpagation medium 207 can be well placed in contact with the examining body 206. Therefore, there is an advantage that it is easy to obtain the ultrasonic image .

However, in the former of the above-mentioned conventional examples, the ultrasonic attenuation coefficient of the silicon rubber used as the ultrasonic propagation medium 103 is as large as about 1.5 dB/mm at the frequency of 3.5 MHz. Moreover, as is apparent from Fig. 1, there is a difference in thickness between the center portion and the both end potions of the ultrasonic propagation medium 103. Therefore, an extremely large sensitivity difference arises between the center portion and the both end portions of the arrayed transducer elements due to the difference of the attenuation in silicon rubber, so that it is impossible to avoid the deterioration of the ultrasonic image. As a result, there is a problem that a sensitivity correcting circuit is indispensable so as to correct the sensitivity difference. On the other hand, in the latter of the above-mentioned conventional excamples, the ultrasonic propagation medium 207 comprising the rubber-made bag 208 which contains the degassed water 209 is placed in contact with the examinig body 206 through a gel (not shown) so as to carry out an ultrasonic diagnosis. However, since the silicon-made bag 208 has a high permeability of water, the degassed water 209 in the bag 208 vaporizes through the silicon rubber-made bag 208 as the time proceeds. Therefore, each time the ultrasonic propagation medium 207 is used, the gassed water 209 must be injected in the bag 208. Moreover, since the bag 208 containing the degassed water 209 is arranged to be thin, this bag 208 is weak against physical impacts. As a result, there is a problem that the bag 208 is occasionally broken so that the degassed water 209 flows to the examining body 206 or the like.

The GB-A-2 009 563 discloses an ultrasonic probe having a structure that a stand-off cell is provided between an ultrasonic wave transducer and a body. Reflection energy is reduced by an inclination at a specific angle of input and output faces of the stand-off cell. The material of the stand-off cell is preferably made of elastomers, in particular natural rubber or polyurethane.

However, the GB-A-2 009 563 gives no hint as to how an ultrasonic propagation medium could be formed so as to improve the characteristics of the ultrasonic probe assembly, in particular with respect to a small ultrasonic attenuation coefficient and an acoustic impedance being close to the impedance of the examining body.

SUMMARY OF THE INVENTION

The present invention has been developed in order to remove the above-mentioned drawbacks inherent to the conventional ultrasonic probe having an ultrasonic propagation medium.

It is, therefore, an object of the present invention to provide an ultrasonic probe having an ultrasonic propagation medium by which an ultrasonic image having a high sensitivity and a high resolving power can be obtained.

Another object of the present invention is to provide an ultrasonic probe having an ultrasonic propagation medium in which the contact of the ultrasonic probe with an examining body and an operability are improved.

In accordance with the present invention there is provided an ultrasonic probe assembly comprising: a body of an ultrasonic probe; and an ultrasonic propagation medium made of rubber, except of silicon rubber, wherein the rubber contains a cross linking agent in an amount of a main component of said cross linking agent of less than 0,8 parts by weight to 100 parts of said rubber, the ultrasonic propagation medium being attached to a portion for transmitting and receiving ultrasonic waves of the body of the ultrasonic probe.

In accordance with the present invention there is further provided an ultrasonic propagation medium comprising rubber mixed with cross linking agent and cross-linked as defined above.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and fatures of the present invention will become more readily apparent from the following detailed description of the preferred embodiments taken in conjunction with the accompanying drawings in

which:

Figs. 1 and 2 are an illustration and a cross-sectional view showing the conventional ultrasonic probes respectively;

Fig. 3 is a cross-sectional veiw showing an ultrasonic probe according to one of the embodiments of the present invention; and

Fig. 4 is a graphic illustration for describing ultrasonic attenuation coefficients with respect to ultrasonic propagation media according to the present invention and comparative examples.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to drawings, an embodiment of the present invention will be described hereinbelow. Fig. 3 is a cross-sectional view of an ultrasonic probe of one embodiment of the present invention.

In Fig. 3, numeral 1 denotes a body of an ultrasonic probe, an array 3 of transducer elements is provided at the lower portion of the body, and the array 3 of the transducer elements has a number of slender plate-like transducer elements linearly successively arranged. An acoustic matching layer 4 having a single or multiple layers is provided on the surface of the array 3 of the transducer elements, and an acoustic lens 5 such as silicon rubber for focussing ultrasonic waves is provided on the front surface of the acoustic matching layer 4. Each of the transducer elements of the array 3 is connected to a body of an ultrasonic diagnostic apparatus (not shown) through lead wires 6 and a cable 7. In this embodiment, an ultrasonic propagation medium 8 is interposed between the acoustic lens 5 and an examining body or a human body 9. The ultrasonic propagation medium 8 is arranged to be larger than the contact area of a portion for transmitting and receiving ultrasonic waves of the body 1 of the ultrasonic probe so that the contact area of the portion is fully covered with the medium 8. The thickness of the medium 8 is about 1 to 2 cm for application to generally flat surface of the examining body 9. In other words, thicker medium 8 may be used for extremely undulatory surfaces of the examining body 9. The acoustic matching layer 4 and the acoustic lens 5 are conventionally used because the acoustic matching layer 4 can transmit ultrasonic waves efficiently and the acoustic lens 5 can focus ultrasonic waves to improve a resolving power, but are not shown in Fig. 2 for simplicity. In this embodiment, the ultrasonic probe having the ultrasonic propagation medium 8 satisfactorily operates irrespective of the presence of the acoustic matching layer 4 and the acoustic lens 5. This ultrasonic propagation medium 8 is made of rubbers such as butadiene rubber which is crosslinked by added peroxide in an amount of 0,8 parts by weight of pure peroxide to 100 parts of butadiene rubber. An acoustic impedance of such ultrasonic propagation medium 8 is close to that of the examining body 9, and an ultrasonic attenuation coefficient of the medium 8 is extremely small.

The operation of the above-mentioned embodiment will be described hereinbelow. Each of the arrayed transducer elements generates ultrasonic waves in order, with pulse voltage transmitted from the body of the ultrasonic diagnostic apparatus through the cable 7 being applied. The resulting ultrasonic waves are emitted to the examining body 9 through the acoustic matching layer 4, the acoustic lens 5, and the ultrasonic propagation medium 8. The ultrasonic waves reflected within the examining body 9 are received by the same transducer element which emits the ultrasonic waves, and are cnverted into electrical signals. The electrical signals are sent to the body of the ultrasonic diagnostic apparatus through the cable 7, and are processed so as to display an ultrasonic image.

Now the components of the ultrasonic propagation medium 8 will be described. First of all an example using butadiene rubber cross-linked by dicumyl peroxide cross linking agent will be described. This dicumyl peroxide cross linking agent is a mixture of 40 parts of dicumyl peroxide used as a main component and 60 parts of calcium carbonate by weight, and is known as KAYAKUMIRU.D-40C produced by Kayaku-Nuri Co.,Ltd. 100 parts of butadiene rubber is mixed by 1.7 parts of dicumyl peroxide cross linking agent (i.e. 0.68 parts of pure dicumyl peroxide) by weight, and the mixture is cross-linked under conditions of a temperature of about 170°c and a time of about 15 min. The acoustic impedance (about 1.44 x 10^5g/cm^2.sec) of the resulting ultrasonic propagation medium 8 is close to that of the examining body 9. Moreover, the acoustic velocity (1570 m/sec) in the ultrasonic propagation medium 8 is also close to that in the examining body 9. Besides, at a frequency of 3.5 MHz, the ultrasonic attenuation coefficient is 0.18 dB/mm. This value is about 1/10 of that of silicon rubber which is 1.5dB/mm.

Fig. 4 is a graph sowing the variation of the ultrasonic attenuation coefficient when varying the amount of dicumyl peroxide cross linking agent which is added to butadiene rubber. In Fig. 4, curves from A to C are obtained by mixtures and treatment thereof as follows.

Composition of Mixtures

	parts of dicumyl peroxide cross linking agent by weight (to 100 parts of butadiene rubber)	parts of pure dicumyl peroxide by weight (to 100 parts of butadiene rubber)
A	0.2	0.08
B	0.85	0.34
C	1.7	0.68

The mixtures are cross-linked under conditions of a temperature of about 170 °c and a time of about 15 min. As is apparent from Fig. 4, ultrasonic attenuation coefficients decrease as the amount of dicumyl peroxide cross linking agent is reduced. When seeing curve A where 0.2 parts of dicumyl peroxide cross linking agent is added, the acoustic attenuation coefficient is 0.12 dB/mm at a frequency of 3.5 MHz, and the acoustic impedance (1.44×10^5 g/cm^2.sec) is equal to that shown by curve C.

As comparative examples, the ultrasonic attenuation coefficient of the conventional silicon rubber, and the ultrasonic attenuation coefficient of valcanized butadiene rubber in which 1.5 parts of sulfur is added to 100 parts of butadiene rubber by weight are respectively shown by curves E and D in Fig. 4. Silicon rubber shown by curve E has a large ultrasonic attenuation coefficient, and moreover, the ultrasonic attenuation coefficient of the sulfur-valcanized butadiene rubber shown by curve D is about 0.3 dB/mm at 3.5 MHz so that the value is larger than those of butadiene rubbers cross-linked by dicumyl peroxide cross linking agent.

On the other hand, the ultrasonic attenuation coefficient of butadiene rubbers has a tendency to increase in accordance with the increment of the amount of dicumyl peroxide cross linking agent. For example, in case that 3.4 parts of dicumyl peroxide cross linking agent (i.e. 1.36 parts of pure dicumyl peroxide) is added to 100 parts of butadiene rubber by weight, the ultrasonic attenuation coefficient is 0.35 dB/mm at 3.5MHz which value is larger than that of the sulfur-valcanized bitadiene rubber (shown by D in Fig. 4). Moreover, in this case, the elasticity of the cross-linked butadiene rubber extremely decreases, and this rubber becomes fragile and crumbly so that this rubber cannot be used practically. The cross-linked butadiene rubber has a low ultrasonic attenuatuion coefficient, and can be used practically, when to 100 parts of rubber, the amount of dicumyl peroxide cross linking agent is set less than 2 parts (i.e. 0.8 parts of pure dicumyl peroxide).

Since the acoustic impedance of the above-mentioned ultrasonic propagation medium 8 is close to that of the examining body 9, there is no mismatching in the vicinity of the examining body 9, thereby preventing the deterioration of the resolving power of images due to multiple reflection. Moreover, the ultrasonic attenuation coefficient is about 1/10 of that of the conventional silicon rubber. Therefore, when the ultrasonic propagation medium 8 of the present invention is used in the trapezoidal scanning type of the ultrasonic probe shown in Fig. 1, the sensitivity variation throughout entire examing region becomes extremely small. As described above, this sensitivity variation is caused by the difference of the thickness between the center portion where the ultrasonic propagation medium 103 is thin and the both end portions where the ultrasonic propagation medium 103 is thick. As a result, it is unnecessary to provide a sensitvity correcting circuit.

As a main component of the ultrasonic propagation medium 8 of the above-mentioned embodiment is used butadiene rubber. However, natural rubber, isoprene rubber, butadiene-styrene rubber, ethylene-propylene rubber, and the like can be also used.

In place of dicumyl peroxide cross linking agent used in the above-mentioned embodiment, benzoyl peroxide, 1,4 (or 1,3)-bis (t-butylperoxy isopropyl) benzene, 2,5-dimethyl-2,5-di (t-butylperoxy) hexane, 1,1-bis-t-butylperoxy-3,3,5-trimethyl cyclohexane, n-butyl-4,4-bis (t-butylperoxy) valerate, t-butylperoxy isopropylcarbonate, and the like can be also used.

Besides, in the ultrasonic propagation medium 8 of the above-mentioned embodiment, butadiene rubber is mixed by dicumyl peroxide cross linking agent in an amount of the main part of the cross linking agent as defined above, and the resulting mixture is coross-linked. Moreover, carbon black, zinc oxide, titanium oxide, silicic anhydride, calcium silicate, colloidal cacium carbonate, or the like can be also added to the mixture of butadiene rubber and dicumyl peroxide cross linking agent so as to bring the acoustic impedance of the ultrasonic propagation medium 8 close to the acoustic impedance of the examining body 9 in the selected range of up to 0,8 parts by weight of pure cross linking agent to 100 parts of rubber. For example, when to the mixture of 100 parts of butadiene rubber and 1.7 parts of dicumyl peroxide cross linking agent, 28 parts of carbon black is mixed by weight, and is cross-linked, the acoustic impedance of the ultrasonic propagation medium 8 becomes 1.65 x 10^5g/cm^2.sec which value is substancially equal to the acoustic impedance (1.5 to 1.6 x 10^5g/cm^2.sec) of the examining body 9. In this case, althrough the ultrasonic attenuation coefficient (0.3 to 0.4 dB/mm at MHz) slightly increases, this value is about 1/5 of that of the conventional silicon rubber so that the resulting ultrasonic propagation medium 8 can be sufficiently used practically. As is apparent from the properties described above, the above-mentioned additives can be also used practically.

In the ultrasonic propagation medium 8, the desirable properties are as follows:

(1) The acoustic impedance is close to the impedance (1.5 to 1.6 x 10^5g/cm^2.sec) of the examining body 9.

(2) The ultrasonic attenuation coefficient is small.

(3) This medium 8 has a low hardness, and an easiness for handling so as to be placed in good contact with the examining body 9.

(4) This medium 8 has chemical stability.

The ultrasonic propagation medium 8 of this invention satisfies the properties of (1) and (2) as is apparent from the detailed description of the above. About (3), the desirable hardness of the medium 8 can be freely obtained by changing the amount of the cross linking agent in the selected range of up to 0,8 parts by weight of pure cross linking agent to 100 parts of rubber. For example, when 2 parts of dicumyl peroxide cross linking agent is added to 100 parts of butadiene rubber by weight, the hardness (Shore hadness A) is about 50. On the other hand, when 0.5 parts of dicumyl peroxide cross linking agent is added to 100 parts of butadiene rubber by weight, the hardness (Shore hardness A) becomes about 30. Moreover, a gel-like medium 8 can be also obtained as well, by decreasing the amount of dicumyl peroxide cross linking agent in the selected range of up to 0,8 parts by weight of pure cross linking agent to 100 parts of rubber. Thus, the ultrasonic propagation medium 8 having a low hardness can be also obtained freely so that the medium 8 which is placed in good contact with the examining body 9 can be obtained. About (4), this medium 8 has a chemical stability so that this medium 8 is stable to water or alcohol which is used very frequently and has no bad effects on the examining body 9.

In this embodiment of the present invention, the ultrasonic propagation medium 8 comprising the cross-liked rubber is interposed between the examining body 9 and the surface of the portion for transmitting and receiving the ultrasonic waves. Therefore, it is unnecessary to inject degassed water into the rubber-made bag each time the bag is used as in the prior art. Moreover, there is no problem of wetting the examining body 9 with the bag being broken by physical impact. Besides, since the acoustic impedance of the medium 8 is close to that of the examining body 9, there is no multiple reflection in the vicinity of the boundary between the medium 8 and the examining body 9. And, since the ultrasonic attenuation coefficient is extremely small, the decrease of the sensitivity due to the use of the medium 8 is small. Moreover, since the ultrasonic propagation medium 8 is soft, the ultrasonic probe can be obtained which is placed in good contact with the examining body 9, has no deterioration of the properties, and has good operability.

In the above-mentioned embodiment, the linear type of the ultrasonic probe and the convex type of the ultrasonic probe have been described. Moreover, the ultrasonic propagation medium 8 can be applied to the duplex type or the like of the ultrasonic probe as well. The ultrasonic propagation medium 8 can be fixed to the surface of the portion for transmitting and receiving the ultrasonic waves of the body 1 of the ultrasonic probe by adhesions or the like, and can be detachably disposed to the bodies of the various types of the ultrasonic probes.

An ultrasonic probe having an ultrasonic propagation medium (8) according to the present invention is used in medical ultrasonic diagnostic systems for examination and inspection of inside of an examining body (9) by transmitting and receiving ultrasonic signals. The ultrasonic probe comprises a body (1), and the ultrasonic propagation medium (8) made of rubber cross-linked by cross linking agent in the selected range of up to 0,8 parts by weight of pure cross linking agent to 100 parts of rubber. The ultrasonic propagation medium (8) is interposed between the examining body (9) and a portion for transmitting and receiving ultrasonic waves of the body (1) of the ultrasonic probe when the ultrasonic propagation medium

(8) is used.

Claims

1. An ultrasonic probe assembly comprising:
   (a) a body of an ultrasonic probe having a portion for transmitting and receiving ultrasonic waves: and
   (b) an ultrasonic propagation medium being attached to said portion and being made of rubber, except of silicon rubber, wherein said rubber contains a crosslinking agent in an amount of a main component of said crosslinking agent of less than 0.8 parts by weight to 100 parts of said rubber.

2. An ultrasonic probe assembly as claimed in claim 1, wherein said rubber is at least one of natural rubber, isoprene rubber, butadiene-styrene rubber, ethylenepropylene rubber, and butadiene rubber.

3. An ultrasonic probe assembly as claimed in claim 1, wherein said cross linking agent is at least one of dicumyl peroxide, benzoyl peroxide, 1,4 (or 1,3)-bis (t-butylperoxy isopropyl) benzene, 2,5-dimethyl-2,5-di (t-butylperoxy) hexane, 1,1-bis-t-butylperoxy-3,3,5-trimethyl cyclohexane, n-butyl-4,4-bis (t-butylperoxy) valerate, and t-butylperoxy isopropylcarbonate.

4. An ultrasonic probe assembly as claimed in claim 1, wherein said ultrasonic propagation medium is detachably disposed to said body of said ultrasonic probe.

5. An ultrasonic probe assembly as claimed in claim 1, wherein a contact surface of said ultrasonic propagation medium is larger than a surface of said portion for transmitting and receiving ultrasonic waves of said body of said ultrasonic probe, said contact surface being contact with said surface of said portion.

6. An ultrasonic propagation medium comprising; rubber, except silicon rubber, cross-linked by cross linking agent, wherein to 100 parts of said rubber, an amount of a main component of said cross linking agent is less than 0.8 parts by weight.

7. An ultrasonic propagation medium as claimed in claim 6, wherein said rubber is at least one of natural rubber, isoprene rubber, butadiene rubber, butadiene-styrene rubber, and ethylene-propylene rubber.

8. An ultrasonic propagation medium as claimed in claim 6, wherein sadid cross linking agent is at least one of dicumyl peroxide, benzoyl peroxide, 1,4 (or 1,3)-bis (t-butylperoxy isopropyl) benzene, 2,5-dimethyl-2,5-di (t-butylperoxy) hexane, 1,1-bis-t-butylperoxy-3,3,5-trimethyl cyclohexane, n-butyl-4,4-bis (t-butylperoxy) valerate, and t-butylperoxy isopropylcarbonate.

Patentansprüche

1. Ultraschallsondeneinrichtung mit
   (a) einem Hauptteil einer Ultraschallsonde, der einen Abschnitt zum Abgeben und Empfangen von Ultraschallwellen hat, und
   (b) einem Ultraschallübertragungsmedium, das an dem erwähnten Abschnitt angebracht und aus Kautschuk mit Ausnahme von Siliconkautschuk hergestellt ist, wobei der erwähnte Kautschuk ein Vernetzungsmittel in einer Menge enthält, die pro 100 Teile des erwähnten Kautschuks weniger als 0,8 Masseteile eines Hauptbestandteils des erwähnten Vernetzungsmittels beträgt.

2. Ultraschallsondeneinrichtung nach Anspruch 1, bei der der erwähnte Kautschuk mindestens einer von Naturkautschuk, Isoprenkautschuk, Butadien-Styrol-Kautschuk, Ethylen-Propylen-Kautschuk und Butadienkautschuk ist.

3. Ultraschallsondeneinrichtung nach Anspruch 1, bei der das erwähnte Vernetzungsmittel mindestens eines von Dicumylperoxid, Benzoylperoxid, 1,4- (oder 1,3-)Bis(*t*-butylperoxyisopropyl)benzol, 2,5-Dimethyl-2,5-di-(*t*-butylperoxy)-hexan, 1,1-Bis-*t*-butylperoxy-3,3,5-trimethylcyclohexan, *n*-Butyl-4,4-bis(*t*-butylperoxy)valerat und *t*-Butylperoxyisopropylcarbonat ist.

4. Ultraschallsondeneinrichtung nach Anspruch 1, bei der das erwähnte Ultraschallübertragungsmedium an dem erwähnten Hauptteil der erwähnten Ultraschallsonde abnehmbar angeordnet ist.

5. Ultraschallsondeneinrichtung nach Anspruch 1, bei der eine Kontaktoberfläche des erwähnten Ultraschallübertragungsmediums größer ist als eine Oberfläche des erwähnten Abschnitts zum Abgeben und Empfangen von Ultraschallwellen des erwähnten Hauptteils der erwähnten Ultraschallsonde, wobei die erwähnte Kontaktoberfläche mit der erwähnten Oberfläche des erwähnten Abschnitts in Kontakt ist.

6. Ultraschallübertragungsmedium, das aus Kautschuk mit Ausnahme von Siliconkautschuk besteht, der durch ein Vernetzungsmittel vernetzt ist, wobei die Menge eines Hauptbestandteils des erwähnten Vernetzungsmittels pro 100 Teile des erwähnten Kautschuks weniger als 0,8 Masseteile beträgt.

7. Ultraschallübertragungsmedium nach Anspruch 6, bei dem der erwähnte Kautschuk mindestens einer von Naturkautschuk, Isoprenkautschuk, Butadienkautschuk, Butadien-Styrol-Kautschuk und Ethylen-Propylen-Kautschuk ist.

8. Ultraschallübertragungsmedium nach Anspruch 6, bei dem das erwähnte Vernetzungsmittel mindestens eines von Dicumylperoxid, Benzoylperoxid, 1,4- (oder 1,3-)Bis(*t*-butylperoxyisopropyl)benzol, 2,5-Dimethyl-2,5-di-(*t*-butylperoxy)-hexan, 1,1-Bis-*t*-butylperoxy-3,3,5-trimethylcyclohexan, *n*-Butyl-4,4-bis(*t*-butylperoxy)valerat und *t*-Butylperoxyisopropylcarbonat ist.

Revendications

1. Ensemble de sonde à ultrasons qui comporte :
   a) Un corps de sonde à ultrasons comportant une partie pour émettre et recevoir des ondes ultrasonores, et
   b) un milieu de propagation des ultrasons fixé à ladite partie et fait de caoutchouc autre que du caoutchouc au silicone, ce caoutchouc contenant un agent de réticulation dont la teneur en composant principal est inférieure à 0,8 parties en poids pour 100 parties du caoutchouc.

2. Ensemble de sonde à ultrasons selon la revendication 1 dans lequel ledit caoutchouc est au moins l'un des éléments suivants: le caoutchouc naturel, un caoutchouc à l'isoprène, un caoutchouc au butadiène-styrène, un caoutchouc à l'éthylène-propylène, et un caoutchouc au butadiène.

3. Ensemble de sonde à ultrasons selon la revendication 1, dans lequel ledit agent de réticulation est au moins un élément parmi: le péroxyde de dicumyle, le péroxyde de benzoyle, le 1,4 (ou 1,3)-bis (t-butylpéroxy-isopropyl) benzène, le 2,5-diméthyl-2,5-di (t-butylpéroxy) hexane, le 1,1-bis (t-butylpéroxy)-3,3,5-triméthyl-cyclohexane, le 4,4-bis (t-butylpéroxy) valérate de n-butyle et le t-butylpéroxycarbonate d'isopropyle.

4. Ensemble de sonde à ultrasons selon la revendication 1, dans lequel ledit milieu de propagation des ultrasons est fixé de façon amovible audit corps de ladite sonde à ultrasons.

5. Ensemble de sonde à ultrasons selon la revendication 1, dans lequel une surface de contact dudit milieu de propagation des ultrasons est plus grande qu'une surface de ladite partie du corps de la sonde à ultrasons servant à transmettre et recevoir les ondes ultrasonores, ladite surface de contact touchant ladite surface de ladite partie.

6. Milieu de propagation des ultrasons comportant du caoutchouc autre que du caoutchouc au silicone, réticulé par un agent de réticulation, dans lequel, pour 100 parties dudit caoutchouc, la teneur en composant principal dudit agent de réticulation est inférieur à 0,8 parties en poids.

7. Milieu de propagation des ultrasons selon la revendication 6, dans lequel ledit caoutchouc est au moins l'un des éléments suivants: le caoutchouc naturel, un caoutchouc à l'isoprène, un caoutchouc au butadiène, un caoutchouc au butadiène-styrène et un caoutchouc à l'éthylène-propylène.

8. Milieu de propagation des ultrasons selon la revendication 6, dans lequel ledit agent de réticulation est au moins un élément choisi parmi: le péroxyde de cicumyle, le péroxyde de benzoyle, le 1,4 (ou 1,3)-

bis (t-butylpéroxy-isopropyl) benzène, le 2,5-diméthyl-2,5-di (t-butylpéroxy) hexane, le 1,1-bis (t-butylepéroxy)-3,3,5-triméthyl-cyclohexane, le 4,4-bis (t-butylpéroxy) valérate de n-butyle et le t-butylpéroxy-carbonate d'isopropyle.

FIG. 1

PRIOR ART

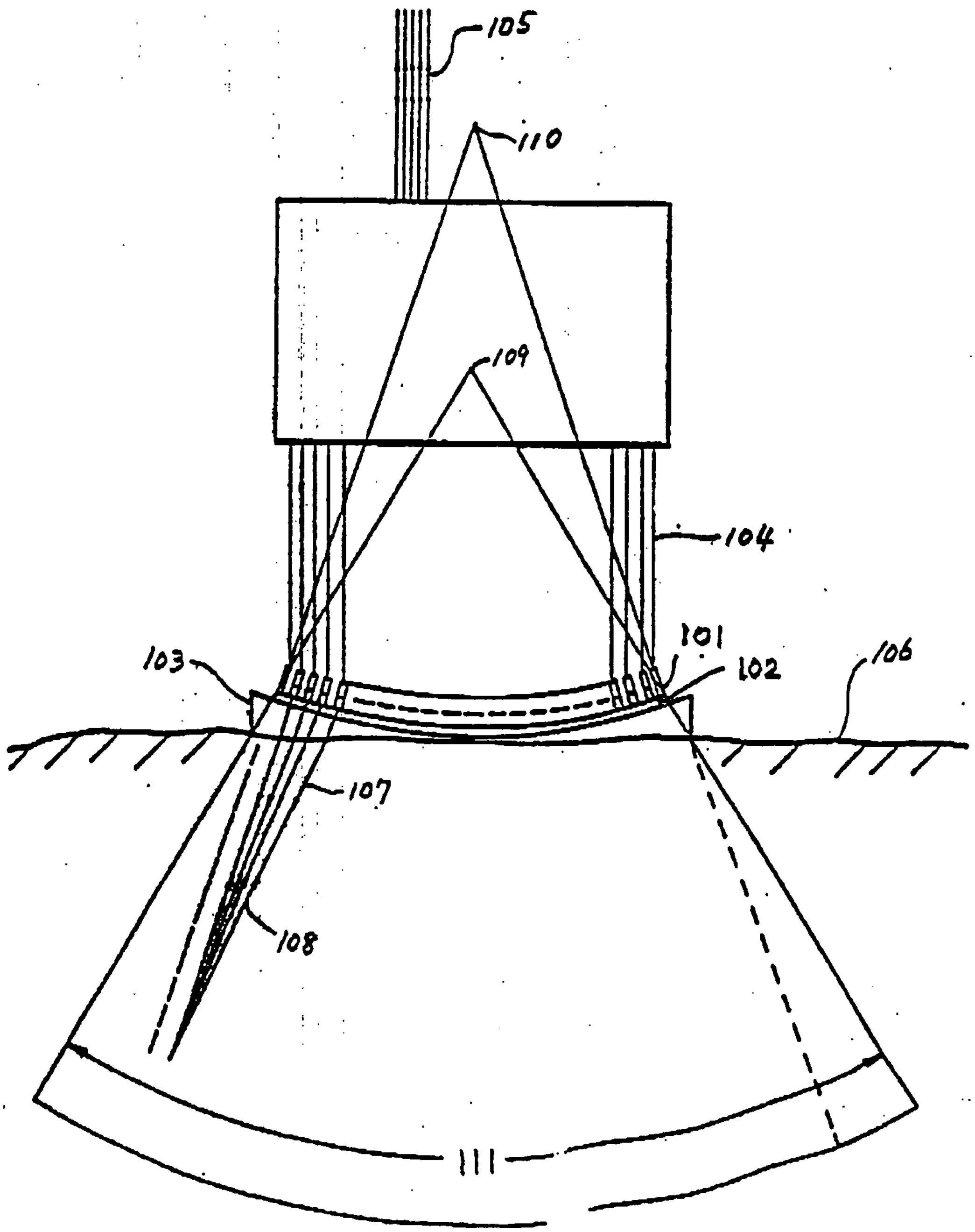


FIG. 2

PRIOR ART

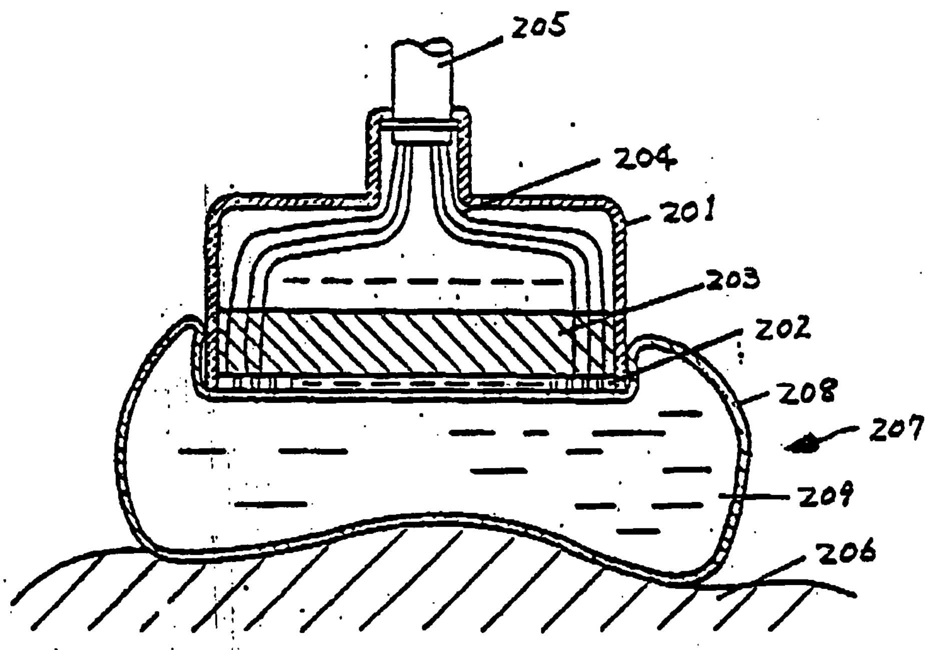


FIG. 3

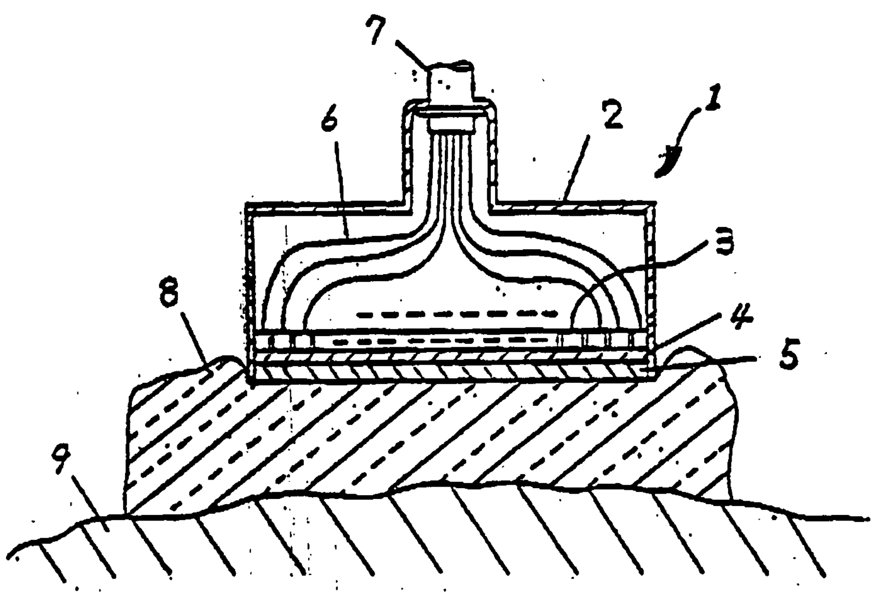
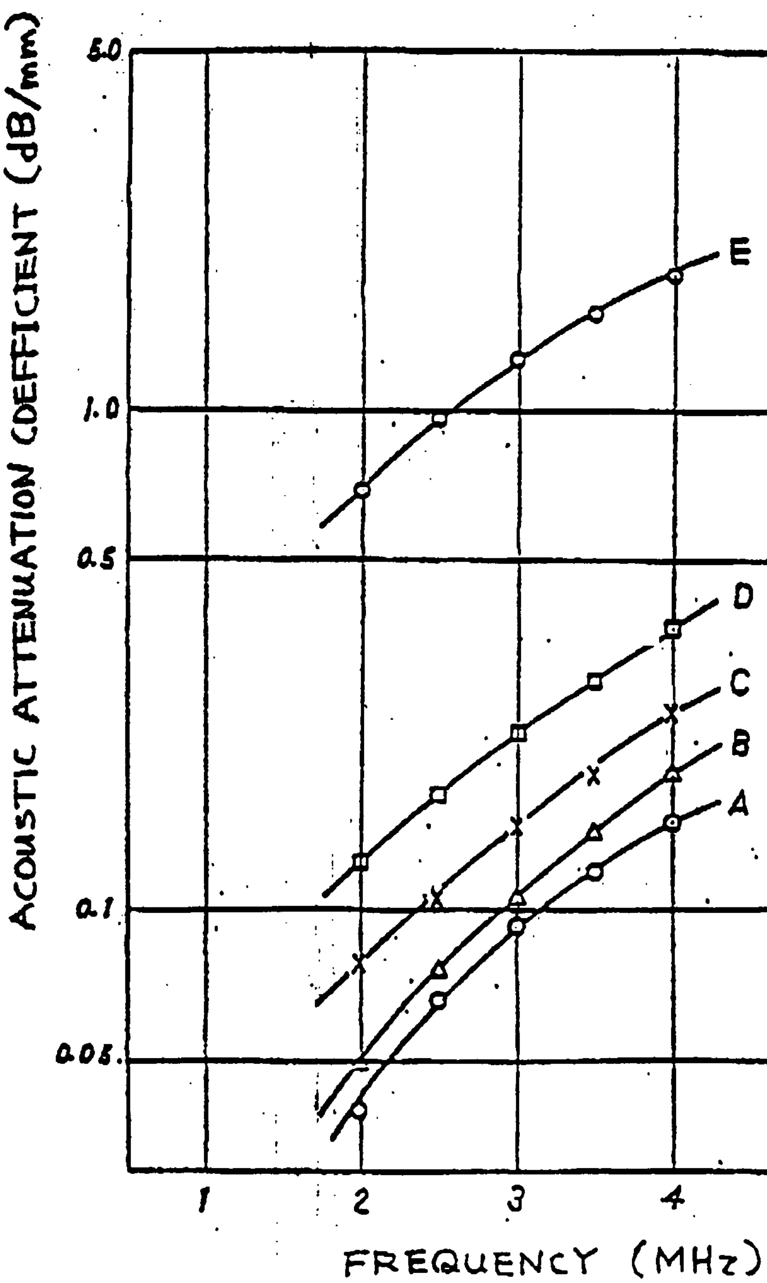


FIG. 4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1.0
0.5
0.1
0.05
E
D
C
B
A
1
2
3
4
5
FREQUENCY (MHz)